TWIN BRIDGE
Iowa Bridges Recording Project
Spanning Little Volga River
in Twin Bridge Park
Fayette Vicinity
Fayette County
Iowa

HAER No. IA-53

BLACK & WHITE PHOTOGRAPHS

REDUCED COPIES OF MEASURED DRAWINGS

WRITTEN HISTORICAL & DESCRIPTIVE DATA

HISTORIC AMERICAN ENGINEERING RECORD
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HISTORIC AMERICAN ENGINEERING RECORD

TWIN BRIDGE

HAER No. IA-53

Location:	Spanning tributary of the Volga River in Twin Bridge Park, 4.2 miles south of Fayette, Fayette County, Iowa UTM: 15.592790.4742850 USGS: Maynard, Iowa quadrangle (7.5 minute series, 1981)
Date of Construction:	c. 1910
Designer:	Daniel B. Luten, Indianapolis, Indiana
Contractor:	N.M Stark and Company, Des Moines, Iowa
Present Use:	Roadway Bridge
Significance:	With its 80-foot span, the Twin Bridge is distinguished as the longest-span Luten arch remaining in Iowa. Its designer, Daniel B. Luten, anticipating the popularity of the reinforced concrete bridge, began acquiring patents in 1900. By the 1910s, thousands of Luten arches had been constructed nationwide. Although highly prolific, his operation was not popular. He was sued for patent infringements and the Iowa State Highway Commission led a nationwide effort to defeat the Luten monopoly, marking the end of the patented-design era, and paving the way for bridge standardization.
Historian:	Juliet Landler, engineer, August, 1995
Project Information:	This document was prepared as part of the Iowa Historic Bridges Recording Project during the summer of 1995 by the Historic American Engineering Record (HAER). The project was sponsored by the Iowa Department of Transportation (IDOT). Preliminary research on this bridge was performed by Clayton B. Fraser of Fraserdesign, Loveland, CO.

The Twin Bridge stands in a shady park surrounded by picnic tables, spanning a tributary of the Volga River. Its construction is simple: a single filled spandrel arch of 80 foot length with an elliptical shape. Two solid abutments, buttressed by wingwalls, anchor the structure. Invisible to the eye, bar reinforcement encased in concrete under the stream bed ties the abutments together, thus reducing the thrust of the flattened arch. Its parapits are constructed out of plain concrete engraved with its designer's signature plain rectangular panel motif. An old coat of whitewash covers the bridge, peeling in places where the concrete has cracked or spalled. In a few spots, the reinforcement is exposed. Despite its decaying condition, the arch is still stable, supporting cars as they enter the park. The bridge no longer carries heavy loads, but for many years this bridge served as an important crossing over the Little Volga River.

The Volga River winds its way East through Fayette county with many offshoots and bends disrupting the orthogonal grid system of the county roads. County planners have always struggled with this river, particularly its circuitous course though the wooded grove of Twin Bridge Park. As far back as 1890 there are requests recorded in the County Supervisor's Minutes that the highway grid be abandoned so that the Volga can be crossed only twice rather than several times as the grid would dictate.[1] Before that time, the county had hesitated to build permanent trails in an area with such difficult terrain. Finally during the 1910s, county officials heeded the advice they had been given twenty years earlier, creating a road that was not straight, but which required only one new crossing. Nearby on an existing road, a bridge across the Volga had been built years previously. Once the second span was constructed, they were commonly referred to as the Twin Bridges. The bridges were hardly identical - one was a metal truss and the other a concrete arch - but were given this nickname only on the basis of their close proximity to each other.

Today only a branch of the Volga flows under the Twin Bridge, however until the 1960s, the main course of the river ran through it. County farmers, with their heavy machinery, found the irregular routing through this part of the section difficult to navigate, and requested that the roads be straightened. County planners agreed that such a change was necessary, but it would require altering the course of the river. With the modern advancements in civil engineering, this proved not to be a great

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[1]Fayette County Supervisors Minutes, Book 6, p.235.

problem. Now only a tributary flows under the Twin Bridge, and the county road bypasses the bridge entirely.

The exact date of the bridge's construction is unclear. Structural reports estimate its construction to be between 1910 and 1916.[2] The year 1916 is listed more than once, but probably this is because that year a fire in the county engineer's office destroyed many original drawings, documents, and records. After the disaster, whenever doubt arouse to an actual construction date, 1916 was assigned. In Fayette County many bridges of similar design were built, and at least six concrete arches remain. The bridges were all constructed between 1910 and 1916 by N.M Stark and Company following a design patented by Daniel B. Luten.

During the early part of the twentieth century, bridge building monopolies were common, and in Fayette County it was the N.M Stark and Company who controlled the empire. From 1900-1916, supervisors awarded Stark about half of the county's bridgework, often in multiple bridge contracts. N.M Stark could build bridges of any span, in concrete or steel, and usually at a price his competitors had trouble beating. Private agreements with several of the more prominent bridge engineers enabled him to use their designs without paying full patent royalties each time. For concrete bridges, his designer was Daniel B. Luten of Indianapolis.

Daniel Luten was an extraordinary businessman in the world of bridge building. Luten graduated with a degree in civil engineering from University of Michigan in 1894 and soon after joined the faculty at Purdue University in Indiana.[3] During this period reinforced concrete technology was just emerging as a field in civil engineering in the United States. This new composite material had been invented in France decades earlier, and Europeans had led in its development. The idea of strengthening concrete with iron had caught on in the United States, but its use was confined primarily to buildings and foundations. Unlike the Europeans, Americans had not yet explored its applications in bridge construction except in a few

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[2]Iowa Department of Transportation, Structure Inventory and Appraisal, Structure No. 150440.

[3]John Wm. Leonard, *Who's Who in Engineering (1922-1923)* New York. 273.

instances.[4] Academia provided Luten the perfect environment in which to become an early authority in this field. In 1900, Luten abandoned his teaching position to devote himself full time to researching and promoting the use of reinforced concrete in bridge construction.[5] Once in private practice, Luten acquired patents rapidly and advertised his work widely.[6]

Luten was an excellent salesman for his bridge designs, and the concrete arch that Twin Bridge typifies was his favorite model. He presented a convincing case as to why concrete arches were the "ideal highway bridge." According to Luten, an ideal highway bridge had twelve requirements:[7]

1. Permanence
2. Artistic appearance
3. Increasing Strength
4. Safety
5. Stability in flood conditions
6. Effective waterway opening
7. Efficient use of materials
8. Employment of home labor and materials
9. Providing continuous roadway
10. Ability to easily widen
11. Ability to easily modify or upgrade
12. Simplicity in design and erection

Luten was convinced that the reinforced concrete arch, more than any other type of bridge, demonstrated these characteristics. He supported his argument with ample evidence and the occasional exaggeration. Regarding the first requirement he claimed, "an arch of concrete has all the permanence of stone; in fact, it is more permanent than the usual building stones." On the subject of aesthetics, he wrote, "since the concrete arch is of pleasing

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[4]Californian E. Ransome built the first reinforced concrete bridge in the United States in San Francisco's Golden Gate Park in 1889. Other early reinforced concrete bridges in the United States were built by Fritz Von Emperger and Heidenreich using technologies they had brought with them from Europe in the 1890s. (David Plowden, *Bridges: The Spans of North America*. 297-99)

[5]Fraserdesign, Introductory Report, Iowa Historic Bridge Survey, p.26.

[6]Articles appeared frequently in journals such as The Railroad Gazette. See list of sources.

[7]Luten. "Arch Design; Specialization and Patents" *Journal of the Western Society of Engineers*. September, 1912, pp.577-603.

form when properly designed, all that is necessary to make it harmonize with its surroundings is to limit the design to dignified details for rugged surroundings, and embellish it with ornamentation for cultivated surroundings. No other bridge harmonizes so readily with its surroundings, no matter what they may be."[8]

Luten held the belief, which was common for his day, that the strength of concrete increased considerably with age, possibly 50% in the first year.[9] The concrete arch also had the advantage that if it failed, it would do so slowly, making it a safer structure, Luten explained. In addition, arches were inherently stable when loaded uniformly in compression. The stress is spread out evenly throughout the cross section of the arch making an efficient use of materials. If the bridge is loaded non-uniformly, or eccentrically, failure might occur in a plain concrete arch due to cracking, but in a reinforced arch, the reinforcement sustains the tensile stresses.[10]

Concrete arches were largely comprised of local materials and demanded little skilled labor for construction. Reinforced concrete arches also could be expanded or modified to reflect progress in the local community, Luten suggested, and he described the process by which a sidewalk or extra lane could be added.[11] In his list of the many attributes of the reinforced concrete arch, he included one drawback - the calculations required in designing the bridge were complex and could take weeks. Luten summarized,

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[8]Luten goes on to say that concrete bridges are certainly not the most beautiful or interesting in blueprint form, but they are the most beautiful in constructed form. (p.579)

[9]Even then construction specifications typically called for a 28 day curing period for the concrete to achieve design strength. The hydration process continues after this time, and the concrete does grow stronger, although early predictions of this increased strength were optimistic. Factors such as creep were not understood at this time.

[10]Luten. 581-583.

[11]On this point he specifically attacked concrete girder bridges saying, "extended use of such a bridge by any community is a standing advertisement of lack of progress, wealth, and road improvement ....and it signifies lack of faith in any future growth. (p.600)

> "from almost every standpoint, therefore, except simplicity in analysis, the concrete arch excels in qualities that go to make an ideal highway bridge. And the one seriously objectionable feature of intricate analysis can be removed by standardization of arch plans; for when an arch of given span and rise has once been analyzed and properly proportioned, the same design, will, of course, satisfy the same requirements for another similar location."[12]

Luten had made the case for the reinforced concrete arch and his standardization of designs for this bridge type simultaneously.

Luten's promotional tactics were tremendously successful. By 1918, over 9000 bridges using his designs were in service, and he had 100 contracting agents operating nationwide. Over 700 Luten bridges had been constructed in Iowa alone, the first having been built in Decorah in 1906.[13] Daniel Luten issued plans and specifications for several different types of concrete bridges, but his elliptical arch design was most popular. Luten's filled spandrel arch designs had roots in the work of Austrian engineers Josef Melan and Fritz von Emperger. In the 1890s Melan received a patent abroad, and von Emperger in the United States, for the placement of stiff steel members in concrete arches. Many of their bridges, known as Melan arches, were built in the United States before the turn of the century. By the time Luten began building bridges, reinforced concrete theory had advanced significantly, and he knew to incorporate less steel and smaller members in his design while using the same basic system for placement. In his elliptical design, the arch was flattened and had spans ranging from 25 feet to over 100 feet. Although longer arches existed, N.M Stark's Twin Bridge with a span of 80 feet distinguishes it as the longest Luten arch remaining in Iowa.[14]

When World War I broke out, Luten had over fifty patents, and his firm had long ceased doing any contracting or construction business. Instead, the National Bridge Company, which he co-owned with his wife and sister-in-law, was occupied almost full-time in the collection of royalties and the pursuit of bridge patent litigation. Luten designs had been built coast to coast,

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[12]p.602.

[13]Luten, "What's Wrong with Iowa?" *Engineering and Cement World*. May 15, 1918, p.29.

[14]Fraserdesign, *Iowa Historic Bridge Inventory*. Structure no. 150440.

and he had court cases pending in almost as great an area. With such a substantial number of patents covering all aspects of bridge construction, it was difficult to build a concrete bridge without infringing upon a Luten patent. Luten insisted that he never filed a suit on basis of infringement alone, "in every case there was on the part of the defendant or others in privity with him some unfair act in aggravation of the infringement."[15] By 1918 Luten had filed at least 59 lawsuits.[16] He advertised his legal battles widely so that all those involved in bridge building would be fore warned of the consequences of using a patented Luten feature in their design. He published pamphlets with descriptions of his more frequently copied patents and synopses of the court settlements in his favor.[17]

Luten's intimidation campaign won him few friends and many enemies. He was especially unpopular with the Iowa State Highway Commission. In 1904 the General Assembly appointed the engineering division at the State College in Ames to be the state highway department, with the duties of investigating and devising new and improved methods of highway construction.[18] Since it was recognized that a substantial portion of county highway funds were being devoted to bridge repairs and reconstruction, this fledgling organization launched a campaign for the replacement of temporary wood and light metal truss bridges with more permanent types. The officials of the Highway Commission disagreed with Luten's assessment that the concrete arch was the "ideal highway bridge." In fact, they believed that the arch form particularly was unsuited to Iowa's soils, and promoted instead the construction of concrete slab and girder bridges. Just after being formed, the Highway Commission launched a campaign for more permanent bridges by circulating state-designed standard plans for bridge types and providing construction demonstrations in various parts of the state.[19]

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[15]"Luten Patent Litigation." Indianapolis, Indiana, March 15, 1918.

[16]Ibid.

[17]Ibid. and Luten Designs. "Luten Patents and Litigation." Indianapolis, February, 1914.

[18]MacDonald, Thos. H. "Bridge Patent and Litigation in Iowa." *Iowa Engineer*. January, 1918, p.118.

[19]Ibid.

When Luten's agents began building concrete arch bridges in Iowa in 1906, the Highway Commission objected. Not only did his operation stifle their efforts to standardize bridge construction statewide, but Luten was rewarded vast sums of Iowa money in the form of royalty payments. Moreover, they contended that his bridge designs and construction methods were unoriginal and his patents invalid. The Highway Commission also denounced his skills as an engineer, claiming that his reinforced arches were hazardous to the public. His agents were attacked with accusations of bid rigging and other illegal activities. A twelve year battle between Luten and the Iowa State Highway Commission ensued. In 1918 the state highway engineer, Thomas MacDonald, defended the Highway Commission's position, "probably ninety percent of bridges built on the Luten patented designs in Iowa were privately let without other plans or other competitions being considered. In fact, in some cases there was not even a written contract covering the transaction. After investigating the type of bridges that were being built under the plan, the Highway Commission refused to approve the construction without decided modifications, which required heavier sections of concrete and greater areas of steel."[20]

The Highway Commission later issued plans of their own for reinforced concrete arches. Their designs looked similar to that of Luten, but had somewhat stockier dimensions.[21]

The staff of the Iowa State Highway Commission more than once came to the support of defendants in Luten's cases.[22] They rationalized their involvement by citing that the State of Iowa lost hundreds of thousands of dollars unnecessarily in royalty

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[20]Ibid. p.120.

[21]C.B. McCullough, Oregon's famous bridge designer, worked for the Highway Commission as a student and young graduate investigating arch design. He wrote an article in support of the Highway Commission's designs(*ISHC Service Bulletin*. Dec., 1914, pp. 3-6.) entitled, "Are the Highway Commission Bridges Too Heavy?"

[22]In a case against the engineer of Buena Vista County in western Iowa, the attorney general and county commissioners had interceded on behalf of the defendant, George B. McCullough. According to a pamphlet Luten published on his patent litigation in 1918, when McCullough revealed upon cross-examination that he had copied a Luten design, his state supporters left the case.

payments to Luten.[23] Of course Luten's rivalry did not make the Highway Commission's work any easier. Already, the Highway Commission did not have widespread support since many farmers equated their work with higher taxes. When the agency was formed in 1904, it was given no authority over county officials, making its mission often difficult, and its longevity uncertain.

Things began to turn around for the Highway Commission in 1913 when it was reorganized and given increased powers. That same year, one year after Luten had filed suit against the Marsh Engineering Company of Des Moines for patent infringement, the state stepped in to take the defendants' side in an attempt to end the era of patented bridge construction in Iowa. Ironically, the bridge upon which this case hinged had been built in Albert Lea, Minnesota. However, a law had been passed, upon advice from the Highway Commission, which entitled the governor to appoint the Attorney General to the defense when such suits were brought against municipalities or contractors of the state.[24] During the six years of litigation, the Highway Commission and its staff, comprised largely of students and staff from Iowa State's Civil Engineering Department, thoroughly researched the evolution of concrete bridge technology in the United States and garnered evidence to help prove the defendants' claim that many of Luten's patents were void for want of invention.[25]

In the case, Luten alleged that a rival, James B. Marsh and his son Frank E. Marsh, had infringed on five patents when they submitted a plan for construction of the bridge at Albert Lea, Minnesota. These inventions included: (1) the use of pavement in the stream bed, (2) the use of an extended spandrel wall with wingwalls, (3) the provision of tension members over the abutments for strengthening the structure at that point, (4) the placement of transverse wires as a restraining device, preventing the tendency of the longitudinal reinforcing rods from pulling

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[23]"End of Bridge Patent Royalty in Sight for Iowa."*Iowa State Highway Commission Service Bulletin*. October, 1916. pp.8-9.

[24]Thomas MacDonald's account of this case from the defense perspective was published in his article, "Bridge Patent Litigation in Iowa." Luten gives his side in "What's Wrong with Iowa," an article published in *Engineering and Cement World,* May 15, 1918.

[25]One student, assigned to research the development of reinforced concrete bridge technology and to gather a bibliography of relevant patents and articles for the case, was Conde B. McCullough.

through the surface of the interior arch, and (5) a method for coping.[26] Many of these ideas are exhibited in Twin Bridge. In addition to pavement under the stream bed to prevent scouring of the abutments, Luten's plans often called for the insertion of 3/4" tension members in the concrete bedding spaced 12" on center to reduce the lateral load on the abutments, thus allowing the abutments to be smaller in size.[27] Luten claimed invention for combining the wingwall and the extended spandrel wall to form a stiffer structure. Since the Twin Bridge's construction drawings have been destroyed or lost, it cannot be stated definitively that the bridge was constructed using these patented ideas. However drawings for a similar arch built by Stark nearby, suggest that variations of these ideas were followed in constructing the bridge.

The wording of Luten's claims was general, which made it easier for him to find grounds on which to sue, but which also ultimately led to his downfall. On January 3, 1918, Judge Martin J. Wade in the District Court of the United States for the Southern District of Iowa returned a decision against Daniel B. Luten in his case against Marsh Engineering Company.[28] Wade dismissed the case against the defendants, stating that the plaintiff and his attorneys did "not come into equity with clean hands," and cited, "half-truths which are worse than falsehoods, in some of the representations made to the contractors."[29] Wade held Luten's patents invalid on the grounds that there were no discoveries, but just applications of existing ideas. He stated,

> "I do feel that somewhere along the progress of the art, when somebody discovered that it was possible to use these rods, and that they might be utilized to good

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[26]"Luten Patents on Concrete Bridges in Iowa Held Invalid." *Engineering and Cement World*. January 15, 1918. p.48.

[27]Luten Designs. "Luten Patents and Litigation." p.5. This was not always used for Luten's elliptical arches since stream or river conditions were inappropriate. For example, in Washington State Luten Arches built over fast running waters had no work under the river bed. (Anderson Bjornstad Kane Jacobs Inc., "Raging River Bridge Report.")

[28]Judge Wade's decision was widely circulated, and appeared in journals such as *Engineering and Cement World* and *The Iowa State Highway Commission Service Bulletin* in January, 1918.

[29]from a copy of Judge Wade's Decision, Luten vs. Marsh Engineering Company, January 3, 1918.

> advantage in particular work, that he may have exercised inventive genius in bringing knowledge to the world; but certainly after the Monier patent, and certainly after the disclosures made by the publications in the field of knowledge in which Mr. Luten worked, and certainly after the extensive discussion and great public interest in the work of reinforcement, I do not believe that anybody who in his structure simply applies well-settled principles of mathematics applied to strain, has any patentable invention."[30]

When Judge Wade handed down the decision against Luten, the era of patented concrete bridge design already was coming to a close. In 1913, the state legislation had mandated that counties adopt the Highway Commission's standardized plans or seek its approval on any alternative plans.

N.M Stark continued building bridges in Iowa for a few years after this date. Stark's operation, based in Des Moines, had extended across the state, and in Story and Marshall Counties he seemed to have enjoyed the preferred bidder status he held in Fayette County. The Highway Commission, however, held Stark in no higher esteem than they held Luten, and attacked his company just as aggressively. Eventually they succeeded in getting this former employee of J.B. Marsh indicted for bid rigging.[31] By 1920, his Iowan empire, like Luten's, had fallen apart.[32]

In recent years, most of Luten's concrete arches have disappeared having lived out the lifespan of an early reinforced concrete bridge. These bridges were never widened or upgraded as Luten had once envisioned, but simply replaced with more modern structures once they were deemed too narrow or too weak. About twenty Luten arches remain in Iowa, the longest of which is Twin Bridge in Fayette County. Although in deteriorating condition today, this elliptical arch, with an 80 foot span and an 80 year service record, is testimony to the fact that its questionable

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[30]Ibid.

[31]N.M. Stark had begun his career, like J.B. Marsh, constructing and designing iron truss bridges for the King Iron Bridge Company of Cleveland, Ohio in the 1880s. When Stark was working as engineer and contracting agent for Nebraska, Wyoming, and Idaho, Marsh was promoted to general contracting agent. *Des Moines Saturday Review*. Feb 11, 1893.

[32]Fraserdesign, *Iowa Historic Bridge Inventory*.

design is much more stable and secure than once thought. Twin Bridge serves as an elegant reminder of the controversial period in the state's history of bridge building in which the transition from privately patented designs to standardized public plans was made.

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ADDENDUM TO
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TWIN BRIDGE

This appendix is an addendum to a 15-page report previously transmitted to the Library of Congress.

APPENDIX: ADDITIONAL REFERENCES

Interested readers may consult the Historical Overview of Iowa Bridges, HAER No. IA-88: "This historical overview of bridges in Iowa was prepared as part of Iowa Historic Bridges Recording Project - I and II, conducted during the summers of 1995 and 1996 by the Historic American Engineering Record (HAER). The purpose of the overview was to provide a unified historical context for the bridges involved in the recording projects."